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Optical scanning device

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Optical scanning device

The present invention relates to an optical scanning device for scanning an information layer of an optical record carrier by means of a radiation beam, the device including

a base plate,

a rotary arm having a first end on a rotation axis and a second end,

an optical system comprising first optical elements arranged in said base plate and second optical elements arranged in said rotary arm, wherein:

said first optical elements comprise a radiation source for supplying said radiation beam, a first mirror for directing said radiation beam towards said second optical elements, and a detection system with a photo-detector for transforming said radiation beam into an electrical signal, and

said second optical elements comprise a second mirror forming with said first mirror a periscope-like arrangement for directing said radiation beam toward the position of said information layer via a third mirror located at said second end of said rotary arm and an objective lens system for converging said radiation beam in the position of said information layer.

It is commonly known in the field of optical storage to provide an optical scanning device with a rotary system including an arrangement of three mirrors. Such a rotary system advantageously allows an electro-mechanically adjustment of a read/write head which is widely used in the HDD industry.

A first type of optical scanning devices with rotary systems is known from, e.g., the international application WO 98/09285. That known device includes first optic elements in a base plate and second optical elements in a rotary arm, a radiation beam being transported between the first and second optical elements by means of optical fibers. A drawback of such an optical device is the alignment accuracy of coupling lenses with respect to the optical fibers. Another drawback is the amount of coupling losses.

A second type of optical scanning devices with rotary systems includes a small, miniaturized optical head comprising integrated optics and electronics such as a radiation source and a detection system. A drawback of that known device is to require advanced manufacturing technology. Another drawback is the relatively high thermal dissipation of the radiation source and of the associated circuitry, which results in thermal problems in the whole device.

A third type of optical scanning devices with rotary systems is known from, e.g., DE 198 60054. That known device includes: a base plate, a rotary arm having a first end on a rotation axis and a second end, and an optical system comprising first optical elements arranged in the base plate and second optical elements arranged in the rotary arm. The known first optical elements comprise a radiation source for supplying a radiation beam, a first mirror for directing the radiation beam towards the second optical elements, and a detection system with a photo-detector for transforming the radiation beam into an electrical signal. The known second optical elements comprise a second mirror forming with the first mirror a periscope-like arrangement for directing the radiation beam toward an information layer via a third mirror located at the second end of the rotary arm and an objective lens system for converging the radiation beam in the information layer. The fixed first mirror and the second rotating mirror are located on the rotary axis of the rotary arm. The third mirror is located at the end of the arm. All other optical elements of the known device, such as the radiation source and the detection system, are located in the fixed base plate.

Fig. 1a shows a first arrangement of the optical elements of the device known from DE 198 60054. It is noted that, when the second and third mirrors are in the configuration in Fig. 1a, the image of the pupil does not rotate on the screen of the detection system, when the latter is aligned with respect to the axis of rotation of the rotary arm. A disadvantage of the configuration shown in Fig. 1a is that it does not allow to optimize the building height of the optical scanning device, because the optical record carrier is in a different plane from that of the fixed first optics.

Fig. 1b shows a second arrangement of the optical elements of the known device, which resolves the problem of building height. However, it is noted that, when the second and third mirrors are in the configuration shown in Fig. 1b, the image of the pupil rotates with respect to the fixed detection system with an angle of rotation equal to twice the angle of rotation of the rotary arm. Therefore, the so-called push-pull signal is not detected properly on the screen of the detection system during the rotation of the rotary system. Fig. 1c shows schematic detailed views of the configuration of the first mirror 1, the second

mirror 2 and the third mirror 3 in the known optical scanning device wherein the image of the pupil on the screen of the detection system rotates with respect to the fixed detection system with an angle of rotation equal to twice the angle of rotation of the rotary arm. Another drawback of the known solution is that it does not allow a proper detection in case of the 3-spot push-pull method since the satellite spots rotates with respect to the fixed detection system when the rotary arm rotates.

An object of the invention is to provide an optical scanning device including a rotary system wherein the rotation of the rotary arm has no effect on the detection of the push-pull signal.

This object is reached by an optical scanning device of the type described in the opening paragraph wherein, according to the invention, said second optical elements further comprise an optical element for flipping the image such that the position of the image on the detector is independent on the rotation of said rotary arm, the flipping element being arranged in the optical path of said radiation beam between said first and third mirrors.

It is noted that such an optical scanning device is particularly advantageous when applied to a so-called SFFO system, i.e. a system suitable for scanning a Small Form Factor Optical disc with a typical diameter of one inch, where a high speed and a noise immunity are required. More specifically, since the electronics for driving the laser and processing the detector signals located on the moving arm, the following problems are resolved: (i) a thermal problem due to the heat dissipation of the radiation source and its associated electronics, (ii) a dynamical problem due to the relatively heavy weight of the optical components, and (iii) an interconnection problem due to the large amount of electrical connections to the laser circuitry and the detection circuitry.

A first embodiment of the flipping element according to the present invention includes a first Dove prism arranged between said second and third mirrors. Dove prisms are commonly known, e.g., from the book "Fundamentals of Optics", F. A. Jenkis, H. E. White, McGraw-Hill Kogakusha, pp.26-27 (4th Edition). It is noted that, by arranging the first Dove prism on the rotary arm, the optical record carrier can be in the same plane as the fixed optical components, while still preserving the non-rotating image on the detection system. It is also noted that the first embodiment also solves a problem of providing an optical scanning device having a minimum building height. This problem is particularly critical when the optical scanning device is applied to an SFFO system.

In a particular case of the first embodiment, a first face of said first Dove prism is used as said second mirror and/or a second face of said first Dove prism is used as said third mirror, which advantageously results in reducing the weight of the rotary arm and thereby increasing the mechanical bandwidth. In another particular case of the first embodiment, at least one of said second and third mirrors is formed by a reflective layer deposited on a face of said first Dove prism. In other words, for any of these particular cases, the second/third mirror and the flipping element are formed by the same component.

A second embodiment of the flipping element according to the present invention includes a fourth mirror and a fifth mirror arranged in the optical path between the second and third mirrors. It is noted that, by arranging the fourth and fifth mirrors on the rotary arm, the optical record carrier can be in the same plane as the fixed optical components, while still preserving the non-rotating image on the detection system.

A third embodiment of the flipping element according to the present invention includes a sixth mirror arranged between said second and third mirrors such that the normal direction to said fourth mirror is substantially perpendicular to the optical axis of the arrangement of said second and third mirrors. It is noted that the third embodiment also solves the aforementioned problem of providing an optical scanning device having a minimum building height. Additionally, the third embodiment also solves a problem of providing an optical scanning device with a rotary system having as fewer components as possible for reasons of dynamic mechanics, thereby optimizing the mechanical bandwidth.

A fourth embodiment of the flipping element according to the present invention is further arranged for rotating the image such that the position of the image on the detector is independent on the rotation of the rotary arm, the flipping element being arranged in the optical path of the radiation beam between said first and second mirrors.

In a particular case of the fourth embodiment, said flipping element includes a second Dove prism rotating together with said rotary arm.

According to a further aspect of the invention, a face of said second Dove prism is used as said second mirror or said second mirror is formed by a reflective layer deposited on a face of said second Dove prism. In other words, for any of these two cases, the third mirror and the flipping element are formed by the same component.

The objects, advantages and features of the invention will be apparent from the following, more detailed description of the invention, as illustrated in the accompanying drawings, in which:

Figs. 1a and 1b show two arrangements of the optical elements of a known device and Fig. 1c shows schematic detailed views associated with a configuration of three mirrors in a known optical scanning device,

Figs. 2a to 2d show four detailed views of the optical components of an optical scanning device according to the invention provided with a rotary arm, and Fig. 2e shows graphs associated with,

Fig. 3a shows schematic detailed views associated with a first embodiment of a flipping element of the device shown in Figs. 2a to 2d,

Fig. 3b and 3c show two schematic detailed views of a particular case of the first embodiment shown in Fig. 3a, in two respective configurations,

Figs. 4a to 4c show schematic detailed views associated with an alternative of the first embodiment shown in Fig. 3a and Fig. 4d shows a graph related to that alternative,

Figs. 5a and 5b show schematic views of the orientation of tracks when scanning with the optical device shown in Figs. 2a to 2d and Fig. 5c shows a graph related to that orientation,

Fig. 6 shows schematic detailed views associated with a second embodiment of a flipping element of the device shown in Figs. 2a to 2d,

Figs. 7a and 7b shows two schematic detailed views of two respective examples of a third embodiment of a flipping element of the device shown in Figs. 2a to 2d,

Figs. 7c to 7e show schematic detailed views associated with the third embodiment shown in Figs. 7a and 7b,

Fig. 8a shows a schematic detailed view of a fourth embodiment of a flipping element of the device shown in Figs. 2a to 2d, and

Fig. 8b shows a schematic detailed view of a particular case of the fourth embodiment shown in Fig. 8a.

Figs. 2a to 2d show four detailed views of the optical components of an optical scanning device according to the invention provided with a rotary arm.

As shown in Fig. 2a, the optical scanning device for scanning an information layer of an optical record carrier by means of a radiation beam includes: a base plate, a rotary

arm having a first end on a rotation axis and a second end (shown in detail in Fig. 2c), an optical system comprising first optical elements arranged in the base plate and second optical elements arranged in the rotary arm. The first optical elements comprise a radiation source for supplying the radiation beam, a first mirror for directing the radiation beam towards the second optical elements, and a detection system with a photo-detector for transforming the radiation beam into an electrical signal. The second optical elements comprise a second mirror forming with the first mirror a periscope-like arrangement for directing the radiation beam toward the position of the information layer via a third mirror located at the second end of the rotary arm and an objective lens system for converging the radiation beam in the position of the information layer. In other words, Fig. 2a illustrates the arrangement of the optical components in the base plate and the rotary arm. The radiation source and the electronics associated with, as well as most of the optical components except for the objective lens, are separated from the rotary arm: a free space propagation of the radiation beam and the telescope-like arrangement are used to guide the light from the radiation source to the objective lens, and vice versa. In the present description such an arrangement is called "split optics".

Fig. 2b illustrates in detail the optical path of the radiation beam in the base plate and the rotary arm via the periscope-like arrangement. The periscope-like arrangement including the first and second 45° mirrors (or prisms) is positioned at the interior of the rotation axis of the rotary arm. The center of those two mirrors is exactly located on the rotation axis of the rotary arm. One mirror of that periscope is attached to the rotary arm. The other mirror is fixed to the first optical elements. The radiation beam is guided from the radiation source via the periscope-like arrangement towards the third 45° mirror and the objective lens at the end of the rotary arm. A separate split optics unit is arranged with the fixed first optical elements; it emits a parallel radiation beam and receives the radiation beam reflected from the information layer for the purposes of data readout and of tracking and focussing control. In this arrangement the radiation beam always stays directed to the head. At the interface between the moving part and the rotating part the radiation beam is exactly centered around the rotation axis.

Fig. 2c illustrates in detail the individual parts of the rotary arm system provided with the periscope-like arrangement described above. The rotary arm provided with a bearing system that consists of two balls, like in the CDM9. One ball is located on the top, the other ball is located on the bottom. The balls are fixed to the moving actuator and are allowed to rotate in a slightly oversized bearing shale. In the present implementation the top

bearing shale is at a high stiffness connected to the base plate in the drive system. The bottom bearing shale is part of a flexure, which preloads the bearing system in vertical direction (along the rotation axis). The preload is such that in the case of shocks of up to 50 g the rotary arm will stay in the bearing system.

Fig. 2d is a detailed side view of the rotary arm illustrating the bearing system. The rotary arm includes an actuation system, a focus suspension system and a Focus drive system.

The actuation system is similar to that of a rotary arm in a HDD system. A coil at one end of the arm is located in a magnetic field, such that one side of the coil is in a vertical upwards field and the other side of the coil is in a vertical downwards field. A current through the coil will generate Lorenz forces, which will finally rotate the arm in the desired direction.

Regarding the focus suspension system, the head consists of an objective lens and a 45° mirror, which are mounted on a lens holder. This lens holder is suspended on two parallel flexures, which allow the lens holder to move in vertical (focus) direction.

Regarding the focus drive system, the drive coil is located at the front of the lens holder. This coil will generate vertical forces in order to bring the lens to the proper focus point. This drive system was described in the European patent application filed on 29 March 2002 with the application number EP 02076224.1.

It is noted that the periscope-like arrangement results in the rotation of the image or pupil when the rotary arm rotates. As a result the +1 and −1 diffraction orders will obtain a different orientation with respect to the fixed world detector geometry. Using only single spot PP radial tracking this problem can be dealt with as long as the pupil's PP-overlap regions are imaged properly onto the 2 detector halves (see Fig. below). When the 2 diffraction orders make a large angle with respect to the 0-order reflection (as is the case for DVR, having a large λ/tp ratio where "tp" is the track pitch), this problem can be overcome. One can show that the maximum rotation angle α that can be obtained in this case equals:

$$\tan(\alpha)=\sqrt{\frac{\lambda^2}{p^2NA^2}-1}$$

So, for DVR (with λ=400 nm, tp=300 nm and NA=0.85) a maximum rotation angle of ± 50.4° would be allowed.

Fig. 2e shows two graphs illustrating a high λ/tp ratio and a low λ/tp ratio.

If 3-spot PP radial tracking is necessary (e.g. to compensate for beam landing), rotation of the rotary arm results in rotation of the 2 satellite spots, around the central detector.

In order to solve this problem, the second optical elements further comprise an optical element for flipping the image such that the position of the image on the detector is independent on the rotation of said rotary arm, the flipping element being arranged in the optical path of said radiation beam between said first and third mirrors. In the present description the "image" is understood as the image on the screen of the detection system of the diffracted radiation beam reflected by the information layer.

Fig. 3a shows schematic detailed views associated with a first embodiment of a flipping element of the device shown in Figs. 2a to 2d. As shown in Fig. 3a, the first embodiment of the flipping element includes a first Dove prism arranged between said second and third mirrors.

Fig. 3b and 3c show two schematic detailed views of a particular case of the first embodiment shown in Fig. 3a, in two respective configurations. As shown in Fig. 3b, a first face of the first Dove prism is used as the second mirror. Furthermore, a second face of said first Dove prism may be used as said third mirror (not shown in Fig. 3b).

The dove prism is built as an extension of the rotating prism in the rotary arm. In terms of building height of the drive, this is the ultimate solution to combine a rotary actuator with the so-called 3-spot PP method described above. Fig. 3b shows the optical path of the three radiation beams (in respect of one main spot and two satellite spots) in case of such a 3-spot system. Fig. 3c shows the actual configuration in the optical scanning device, the fixed prism being rotated of an angle of 90° with respect to the position shown in Fig. 3b.

As an alternative of the case shown in Fig. 3b, at least one of said second and third mirrors is formed by a reflective layer deposited on a face of said first Dove prism. Figs. 4a to 4c show schematic detailed views associated with the first embodiment shown in Fig. 3a in the case where the first Dove prism is asymmetrical. Fig. 4d shows a graph related to that case.

Fig. 4a shows a detailed view of the first Dove prism in the form of an asymmetrical prism. It is noted that such a prism advantageously results in reducing the weight of the rotary arm and thereby increasing the mechanical bandwidth. However, such a prism introduces deformation when the roatary arm rotates and consequently the image rotates but over an angle smaller than the angle of rotation of the rotary arm.

With reference to Fig. 4b, the distortion angle due to the asymmetrical prism can be calculated as follows. Consider that the assymetrical prism is made of a material having a refraction index n and a first angle θ1 with repect to a base of the prism. Then the angle of incidence i equals 90-θ1 and the angle of refraction t equals arcsin[sin(90-θ1)/n]. The angle of reflection on said base of the prism φ then equals 90-θ1-t. Thus the second angle θ2 with repect to the base of the prism is defined as follows:

$$\theta 2 = \tfrac{1}{2}\theta 1 + \tfrac{1}{2}\arcsin\left[\frac{\sin(90-\theta 1)}{n}\right] \tag{1}$$

By way of illustration only, in the case where 30°<θ1<60°, it results from Equation (1) that: 28°<θ2<38°. The magnification M of the prism equals cos(t)/cos(i). Thus the theoretical minimum length L of the prism is defined as follows:

$$L = x/\tan(\varphi)+(x+d)/\tan(\varphi)+Md$$

It is noted that a high value of the magnification M results in a high value of distortion of the image upon rotation of the rotary arm over an angle α.

Fig. 4b illustrates such a deformation of the image which can be defined by two angles φ_x and φ_y. The angles φ_x and φ_y are given by the following equations:

$$\varphi_x = \arctan[M\tan(90-\alpha)]-(90-\alpha) \tag{2a}$$

$$\varphi_y = \arctan[M\tan(\alpha)]-\alpha. \tag{2b}$$

By way of illustration only, in the case where θ1=45°, n=1.5, x=0.1 mm, d=1.3mm, α<15°, θ2=36.6°, M=1.25 and L=6.6mm, it results from Equations (2a) and (2b) that φ_x=2.9° and φ_y=3.5°.

It is noted that the higher the refraction index n, the smaller the length L, but the larger the magnification M and therefore the distortion, i.e. the angles φ_x and φ_y.

Fig. 4c illustrates the relationship between the maximum distortion angle and the length L of the prism for different values of the refraction index n in the case where d=1.3mm and x=0.1mm.

By way of illustration only, examples of materials of the first Dove prism are now described. For dynamic reasons, that material has preferably a high refraction index in order to keep the length L of the prism small. Thus, such a material may be one of the following:

LAK10	n_{400} = 1.744
LASFN31	n_{400} = 1.918

where "n_{400}" is the value of the refraction index n in the case where the wavelength of the radiation beam is equal to 400nm. Mostly however, it is better to keep the distortion small, regardless of the size and the weight of the prism. Then a material with a low refraction index should be preferably used. Thus, such a material may be one of the following:

BK7	$n_{400} = 1.530$
FK5	$n_{400} = 1.499$

More preferably that material should be plastic rather than glass, thereby limiting the weight while the refraction index n_{400} remains small. Thus, such a material may be one of the following:

COC (cyclo olefinic copolymer)	$n_{400} = 1.550$
PMMA	$n_{400} = 1.507$

Figs. 5a and 5b show schematic views of the orientation of tracks when scanning with the optical device shown in Figs. 2a to 2d and Fig. 5c shows a graph related to that orientation.

The push pull signal generated from the radiation beam reflected on the information layer is assumed to have a fixed orientation with respect to the detection system. When describing a straight line with the optical head, this can indeed be achieved. However with the rotary arm, the optical head will describe an arc, as shown in Fig. 5a. Over this arc, the orientation of the tracks with respect to the fixed first optical elements will not be constant. The difference in angle between the tracks and a fixed reference depends on the position of the rotation axis and the length of the rotary arm. The optimal position of the rotation axis is given in Fig. 5b. The head should be on a radial line (through the center of the disc) at the inner data radius, and the rotation axis must be on a line perpendicular on the radial line through the center data radius. Then the tracks at the inner and outer data radius are perpendicular to the radial line. In between, the tracks are not perpendicular, but have a small angle. In the case where Rin=6 mm, Rout=14mm, and the length of the rotary arm equals 15mm, the maximum angle is 3.2°. The detection system can be positioned to have an angle with respect to the inner data track, such that the variation in angle will be from –1.6 to 1.6° rather than from 0 to 3.2°. The course of the angle for this case is shown in Fig. 5c. The maximum of 1.6° is small enough for use with the so-called push-pull method.

Fig. 6 shows schematic detailed views associated with a second embodiment of a flipping element of the device shown in Figs. 2a to 2d. As shown in Fig. 6, the second embodiment of the flipping element includes a fourth mirror and a fifth mirror which are arranged between said second and third mirrors. It is noted that the second embodiment

provides a smaller building height than the building height of the optical scanning device shown in Fig. 1a.

Figs. 7a and 7b shows two schematic detailed views of two respective examples of a third embodiment of a flipping element of the device shown in Figs. 2a to 2d. Figs. 7c to 7e show schematic detailed views associated with the third embodiment shown in Figs. 7a and 7b. As shown in Figs. 7a and 7b, the second embodiment of the flipping element includes a sixth mirror arranged between said second and third mirrors such that the normal direction to said fourth mirror is substantially perpendicular to the optical axis of the arrangement of said second and third mirrors.

It is noted in Fig. 7a that the sixth mirror is arranged on a first side of the rotary arm, in a plane perpendicular to the axis of rotation of the rotary arm (first example). Fig. 7d also shows that configuration of the sixth mirror.

It is noted in Fig. 7b that the sixth mirror is arranged on a second, perpendicular side of the rotary arm, in a plane parallel to the axis of rotation of the rotary arm (second example). Fig. 7e shows the configuration with the third mirror on a vertical plane.

In other words, for both examples shown in Figs. 7a and 7b, the sixth mirror in the rotating arm on the inside of the radiation beam and alternatively this mirror can be on another side of the radiation beam such that the radiation beam propagates between the second and third mirrors. Furthermore, the second and third mirrors must be tilted in such a way that the radiation beam reflects on the sixth mirror rather than propagating directly between the second and third mirrors. The required tilt angle of the two existing mirrors, and the angle of the third mirror can be calculated. With reference to Fig. 7c, "L_{arm}" is the distance between the axis of rotation and the center of the objective lens, "H_{arm}" is the height of the rotary arm, "d" is the diameter of the radiation beam, "α" is the angle between the normal directions of the second/third mirror and the sixth mirror, and "L_{mirror}" is the minimum length of the sixth mirror. The angle α and the length L_{mirror} are given by the following equations:

$$\alpha = \frac{1}{2}\arctan\left(\frac{L_{arm}}{2H_{arm}}\right) \tag{3a}$$

$$L_{mirror} = \frac{d}{\sin(90-2\alpha)} \tag{3b}$$

By way of illustration only, in the case where L_{arm}=15mm, d=1.5mm, and H_{arm}=1.6mm, it results from Equations (3a) and (3b) that α=39° and L_{mirror}=7.2 mm.

Fig. 8a shows a schematic detailed view of a fourth embodiment of a flipping element of the device shown in Figs. 2a to 2d. As shown in Fig. 8a, the fourth embodiment of the flipping element is further arranged for rotating the image such that the position of the image on the detector is independent on the rotation of the rotary arm, the flipping element being arranged in the optical path of the radiation beam between said first and second mirrors. In a particular case of the fourth embodiment, said flipping element includes a second Dove prism rotating together with the rotary arm, as shown in Fig. 8a.

Fig. 8b shows a schematic detailed view of a particular case of the fourth embodiment shown in Fig. 8a. In the case shown in Fig. 8b, a face of said second Dove prism is used as said second mirror. Alternatively, said second mirror is formed by a reflective layer deposited on a face of said second Dove prism.

It is noted that, in order to avoid any rotation of the laser beam pupil, when traversing the periscope, the second Dove prism can be positioned between the first and second mirrors of the periscope-like arrangement. When the rotary arm is rotated, the second Dove prism is also rotated but with half the rotation velocity of the rotary arm. In this way the orientation of the pupil of the laser beam does not change. Consequently, in the forward path and in the return path no additional problems arise and, one can use conventional split optics using 3-spot PP radial tracking.

It is noted that the embodiment shown in Fig. 8b provides a smaller building height than the embodiment shown in Fig. 8a.

It is noted that the four embodiments of the flipping element described above can be advantageously applied to a so-called SFFO system.

CLAIMS:

1. An optical scanning device for scanning an information layer of an optical record carrier by means of a radiation beam, the device including

a base plate,

a rotary arm having a first end on a rotation axis and a second end,

an optical system comprising first optical elements arranged in said base plate and second optical elements arranged in said rotary arm, wherein:

said first optical elements comprise a radiation source for supplying said radiation beam, a first mirror for directing said radiation beam towards said second optical elements, and a detection system with a photo-detector for transforming said radiation beam into an electrical signal, and

said second optical elements comprise a second mirror forming with said first mirror a periscope-like arrangement for directing said radiation beam toward the position of said information layer via a third mirror located at said second end of said rotary arm and an objective lens system for converging said radiation beam in the position of said information layer, characterized in that said second optical elements further comprise an optical element for flipping the image such that the position of the image on the detector is independent on the rotation of said rotary arm, the flipping element being arranged in the optical path of said radiation beam between said first and third mirrors.

2. An optical scanning device according to claim 1, wherein said flipping element includes a first Dove prism arranged between said second and third mirrors.

3. An optical scanning device according to claim 2, wherein a first face of said first Dove prism is used as said second mirror and/or a second face of said first Dove prism is used as said third mirror.

4. An optical scanning device according to claim 2, wherein at least one of said second and third mirrors is formed by a reflective layer deposited on a face of said first Dove prism.

5. An optical scanning device according to claim 1, wherein said flipping element includes a fourth mirror and a fifth mirror which are arranged between said second and third mirrors.

6. An optical scanning device according to claim 1, wherein said flipping element is formed by a sixth mirror arranged between said second and third mirrors such that the normal direction to said fourth mirror is substantially perpendicular to the optical axis of the arrangement of said second and third mirrors.

7. An optical scanning device according to claim 1, wherein said flipping element is further arranged for rotating the image such that the position of the image on the detector is independent on the rotation of the rotary arm, the flipping element being arranged in the optical path of the radiation beam between said first and second mirrors.

8. An optical scanning device according to claim 7, wherein said flipping element includes a second Dove prism rotating together with said rotary arm.

9. An optical scanning device according to claim 8, wherein a face of said second Dove prism is used as said second mirror.

10. An optical scanning device according to claim 8, wherein said second mirror is formed by a reflective layer deposited on a face of said second Dove prism.

ABSTRACT:

An optical device for scanning an information layer includes: a base plate, a rotary arm having a first end on a rotation axis and a second end, an optical system comprising first optical elements arranged in the base plate and second optical elements arranged in the rotary arm. The first elements comprise a radiation source for supplying a radiation beam, a first mirror for directing the radiation beam towards the second elements, and a detection system. The second elements comprise a second mirror forming with the first mirror a periscope-like arrangement, a third mirror arranged at the second end, and an objective lens system for converging the radiation beam in the information layer. The second optical elements comprise an optical element arranged between the first and third mirrors, for flipping the image such that the position of the image on the detector is independent on the rotation of the arm.

Fig. 3a

Fig. 1a (prior art - first configuration)

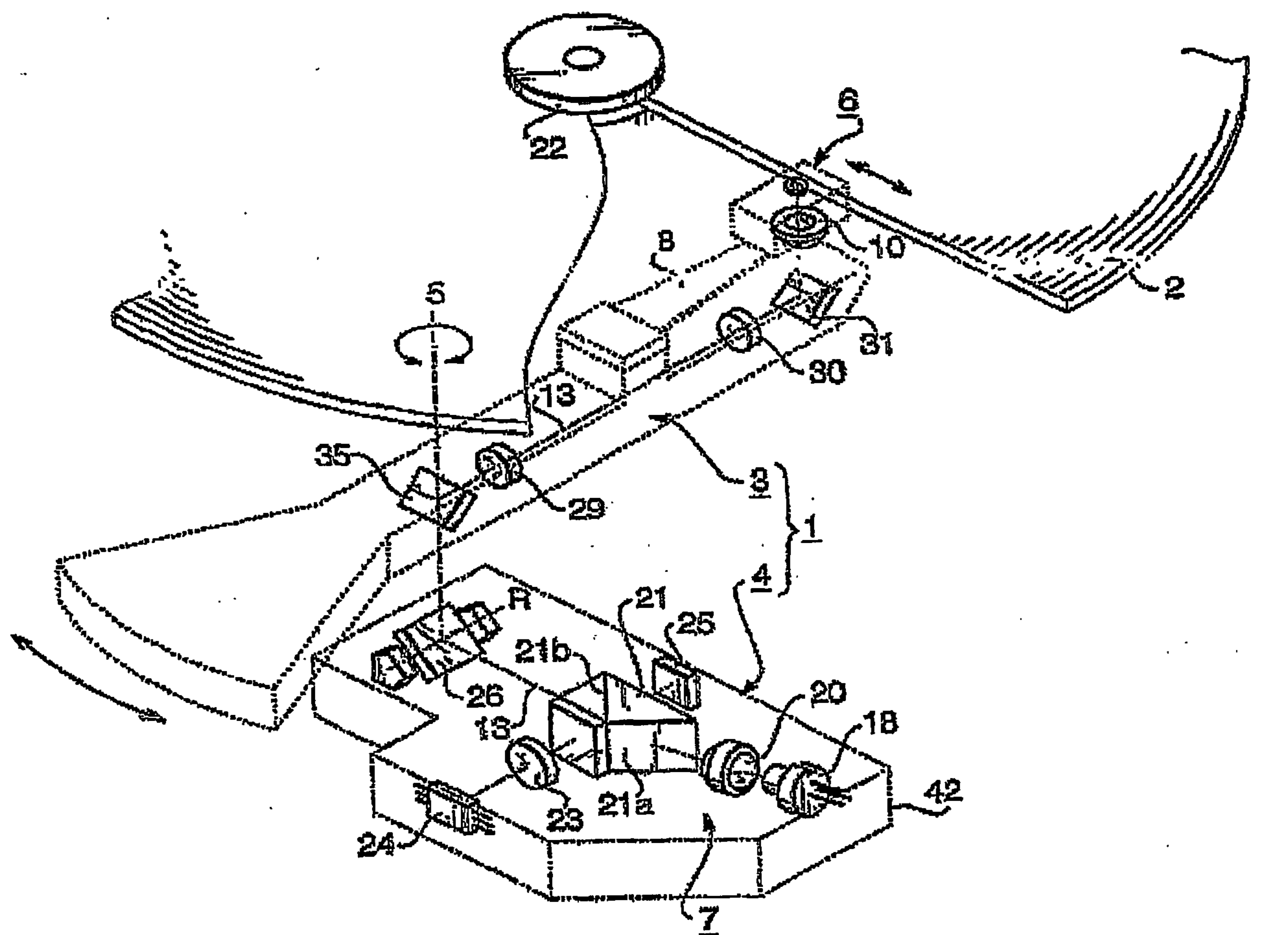


Fig. 1b (prior art - second configuration)

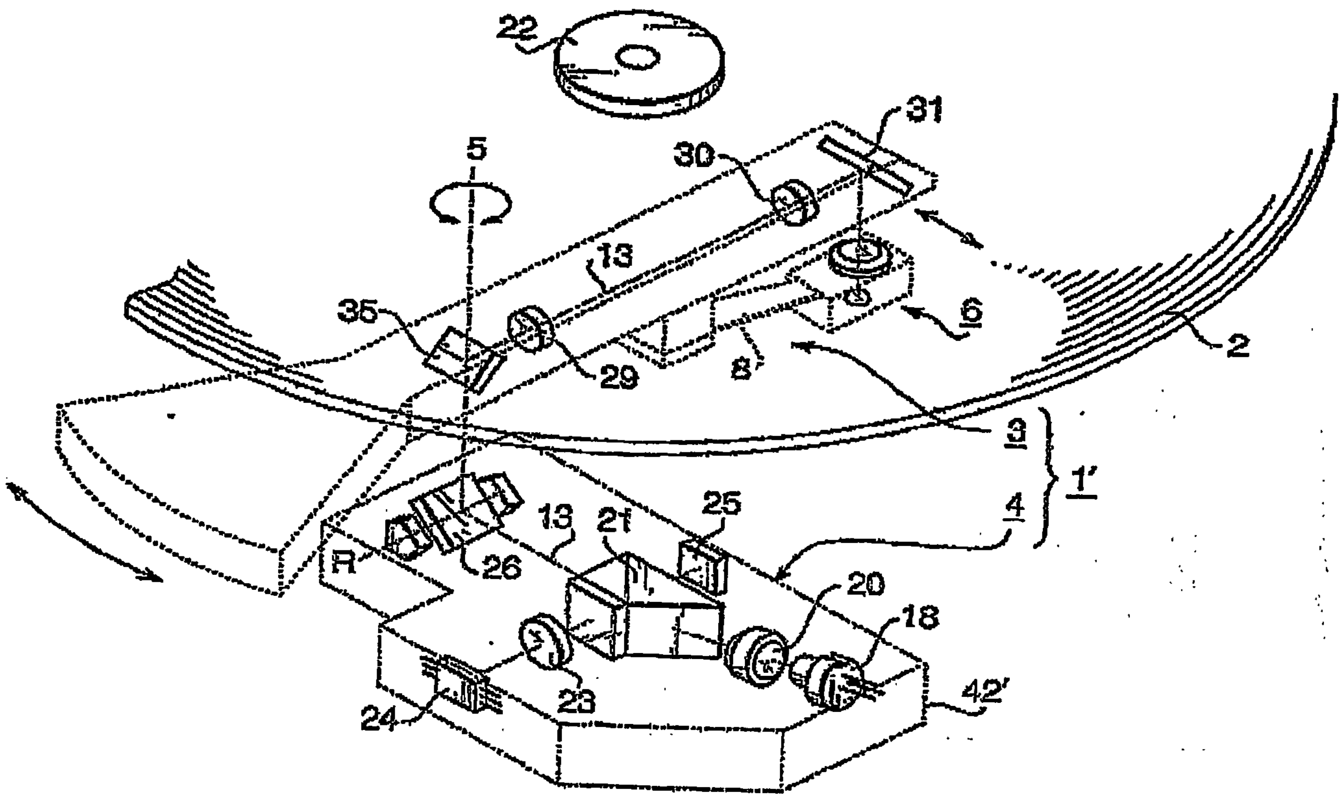
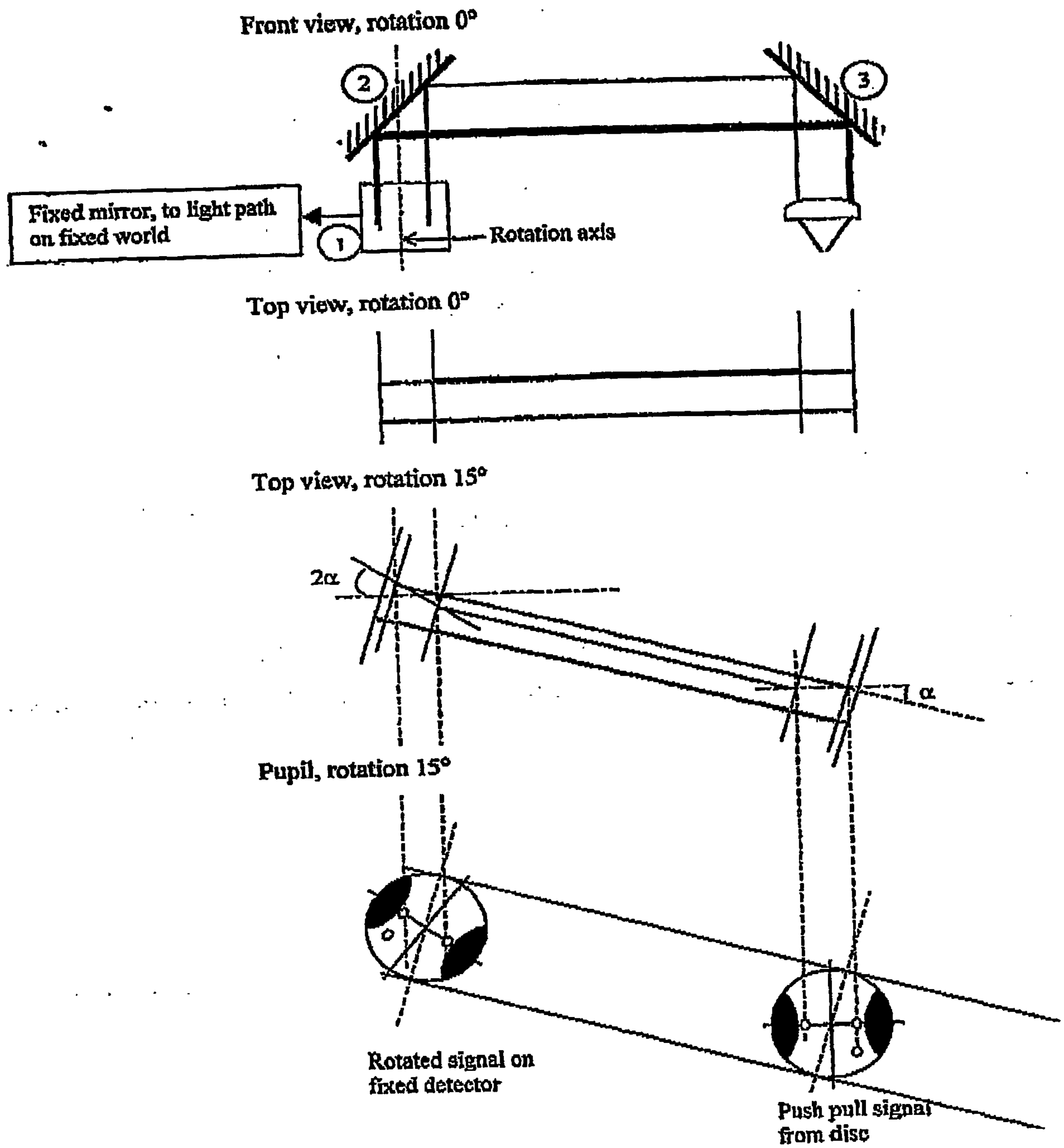


Fig. 1c (prior art - detailed views)

Problem with rotary arm: pupil rotates on detector in fixed world.



Schematic view of configuration with symmetrical mirrors. When the arm rotates over an angle α, the image rotates over an angle 2α on the detector.

Fig. 2a (optical scanning device - first view)

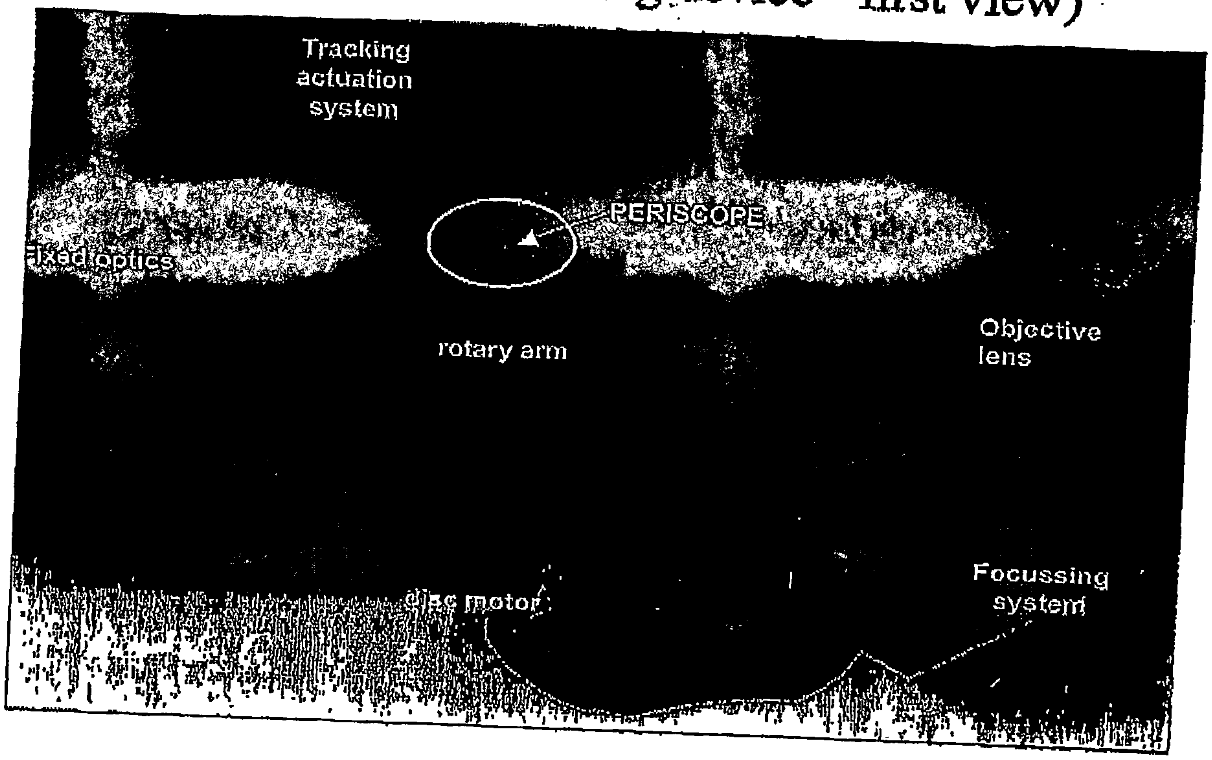


Fig. 2b (optical scanning device - second view)

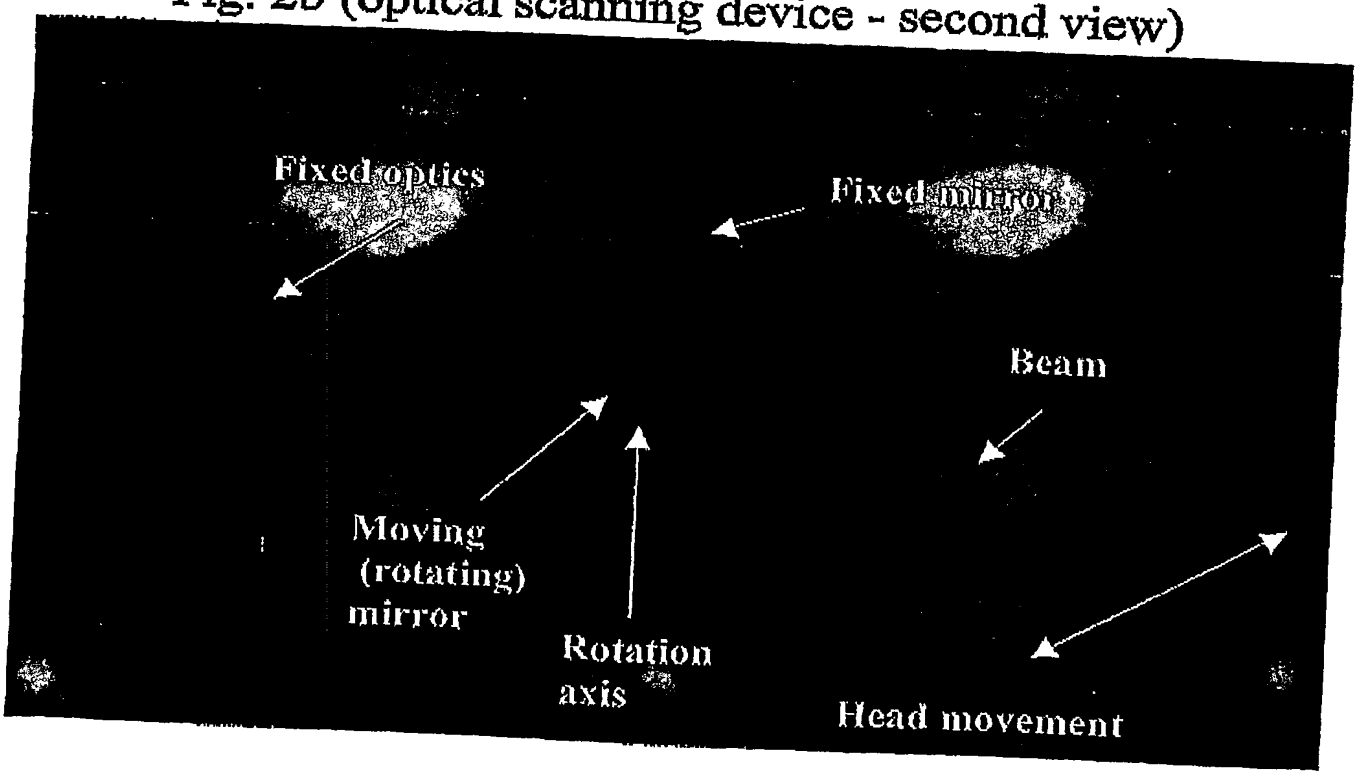


Fig. 2c (optical scanning device - third view)

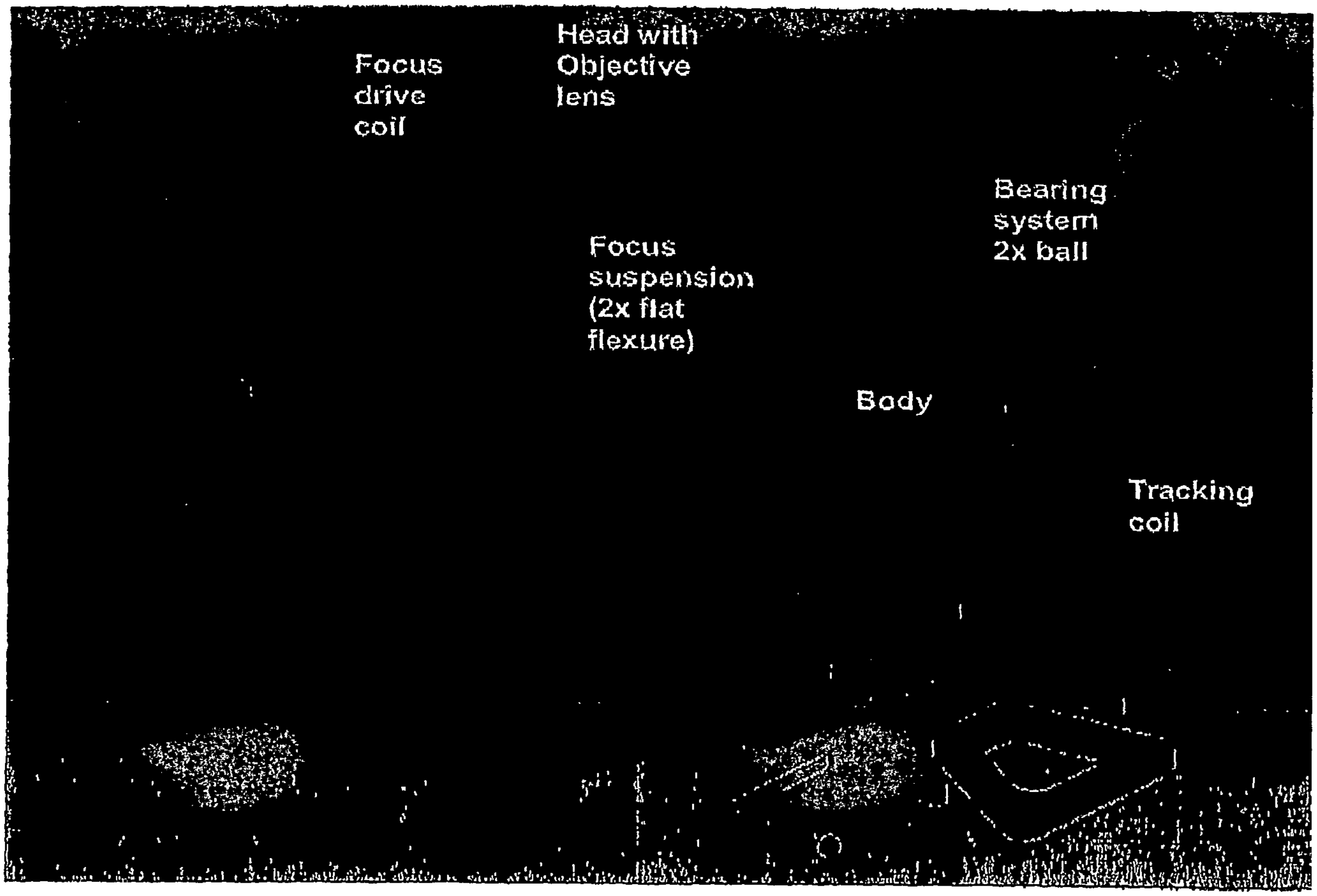


Fig. 2d (optical scanning device - fourth view)

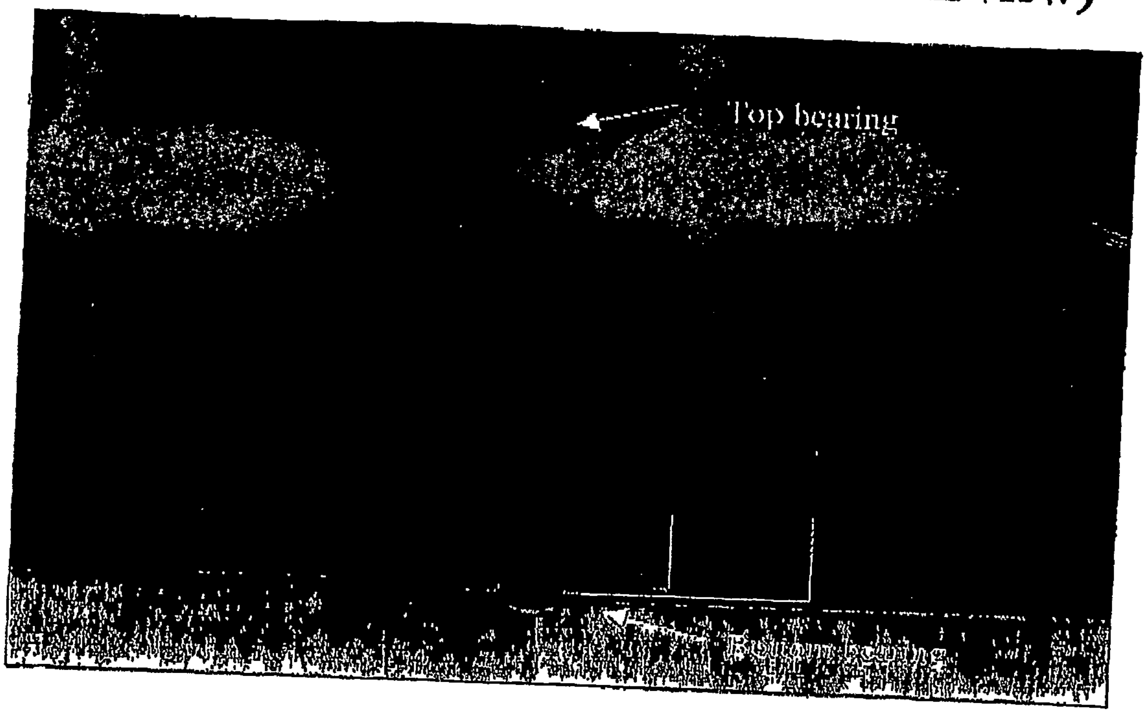


Fig. 2e (optical scanning device - graphs)

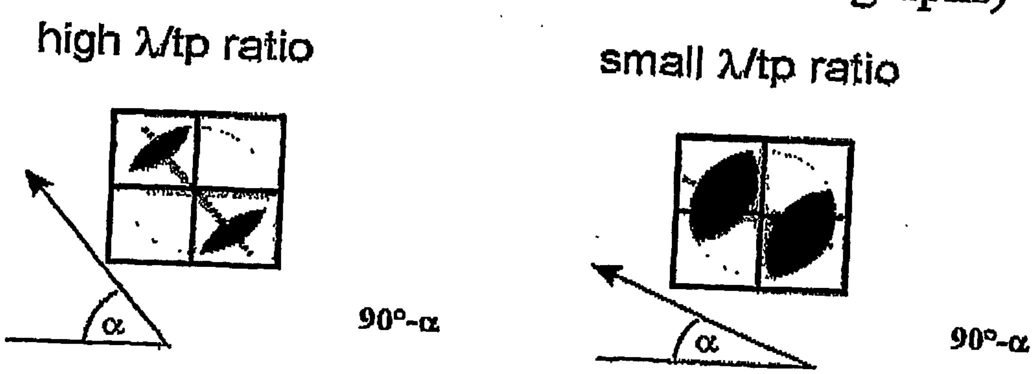


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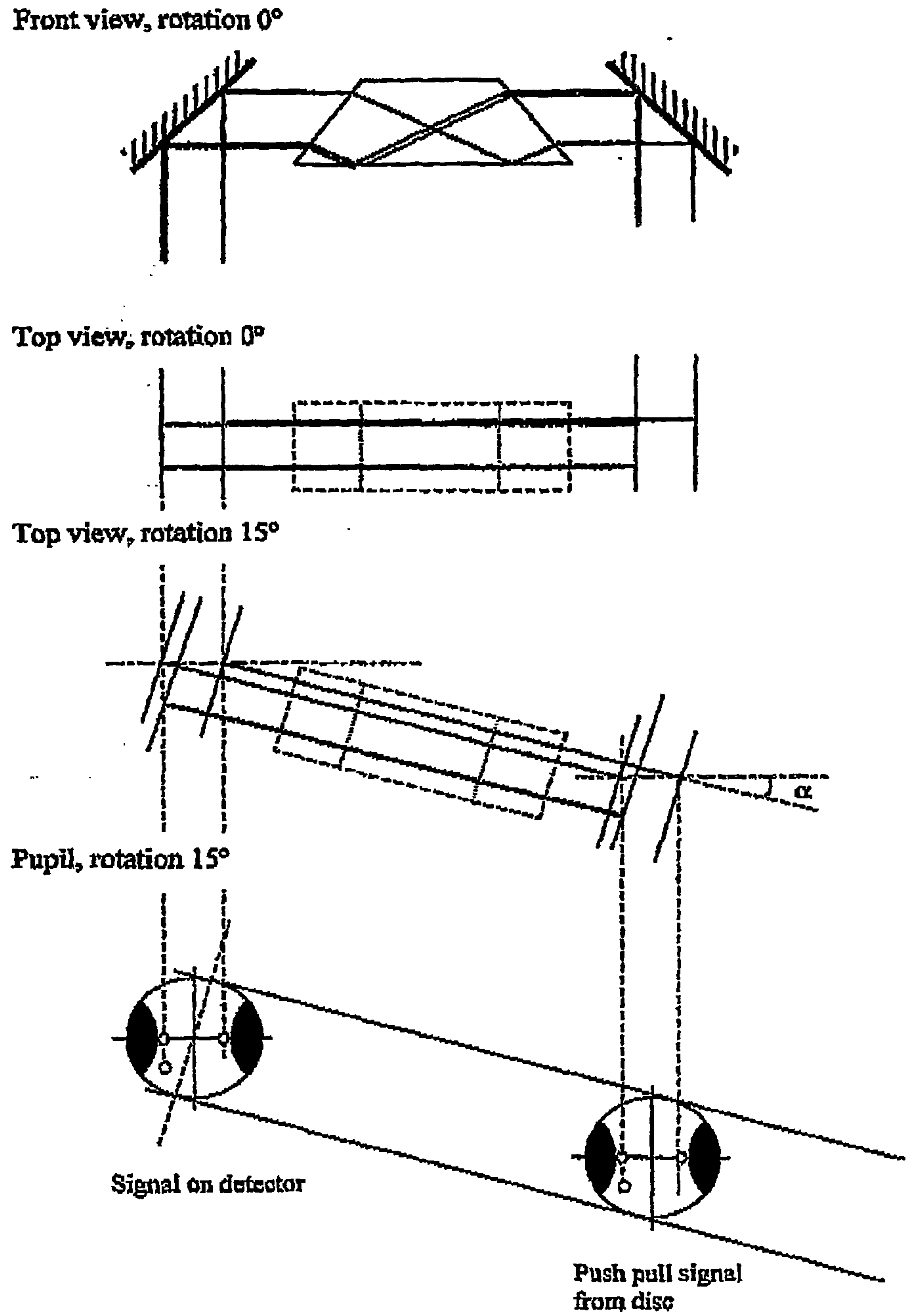
Fig. 3a (first embodiment - detailed views)

Use Dove prism, pupil remains unchanged on detector. This solution has advantages for building height.



. Solution with dove prism. This solution gives the smallest building height.

Fig. 3b (first embodiment - particular case)

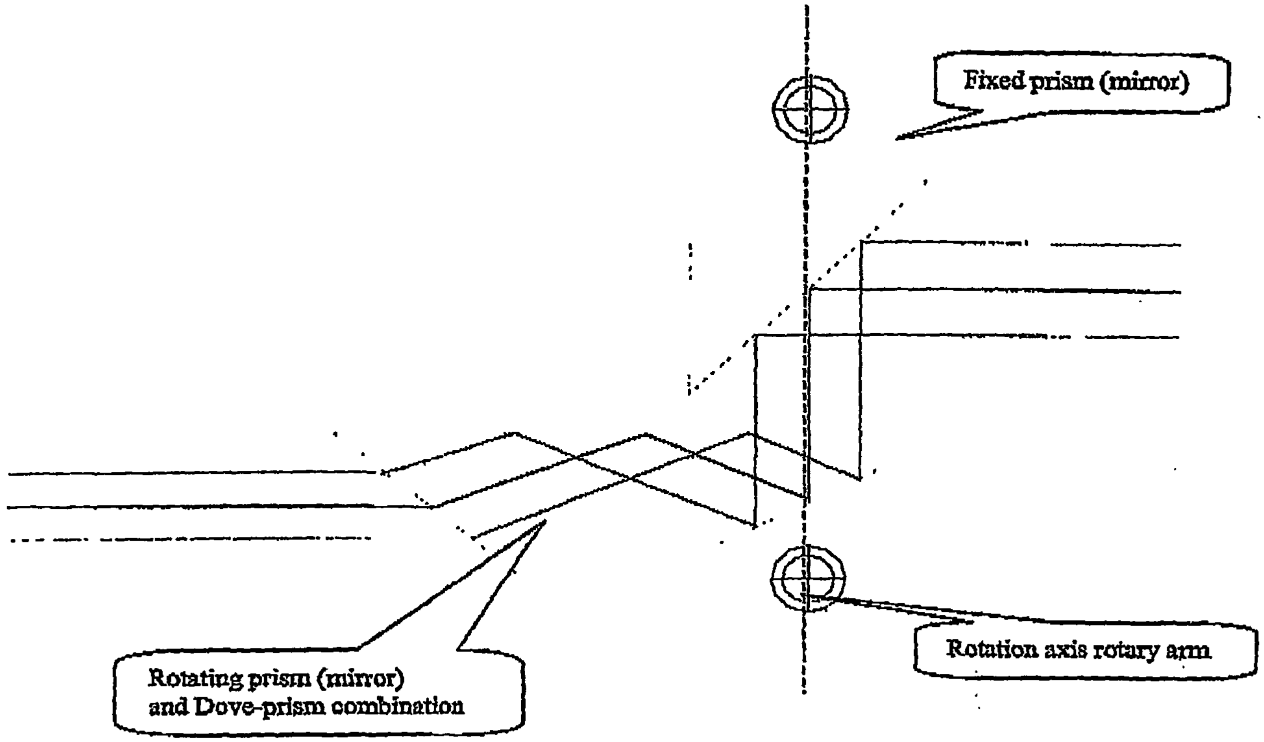


Fig. 3c
(first embodiment - particular case - other configuration)

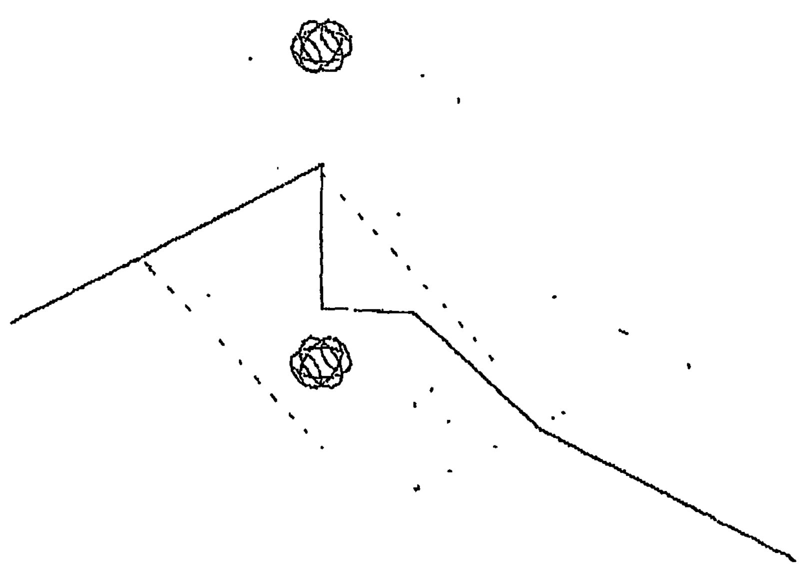
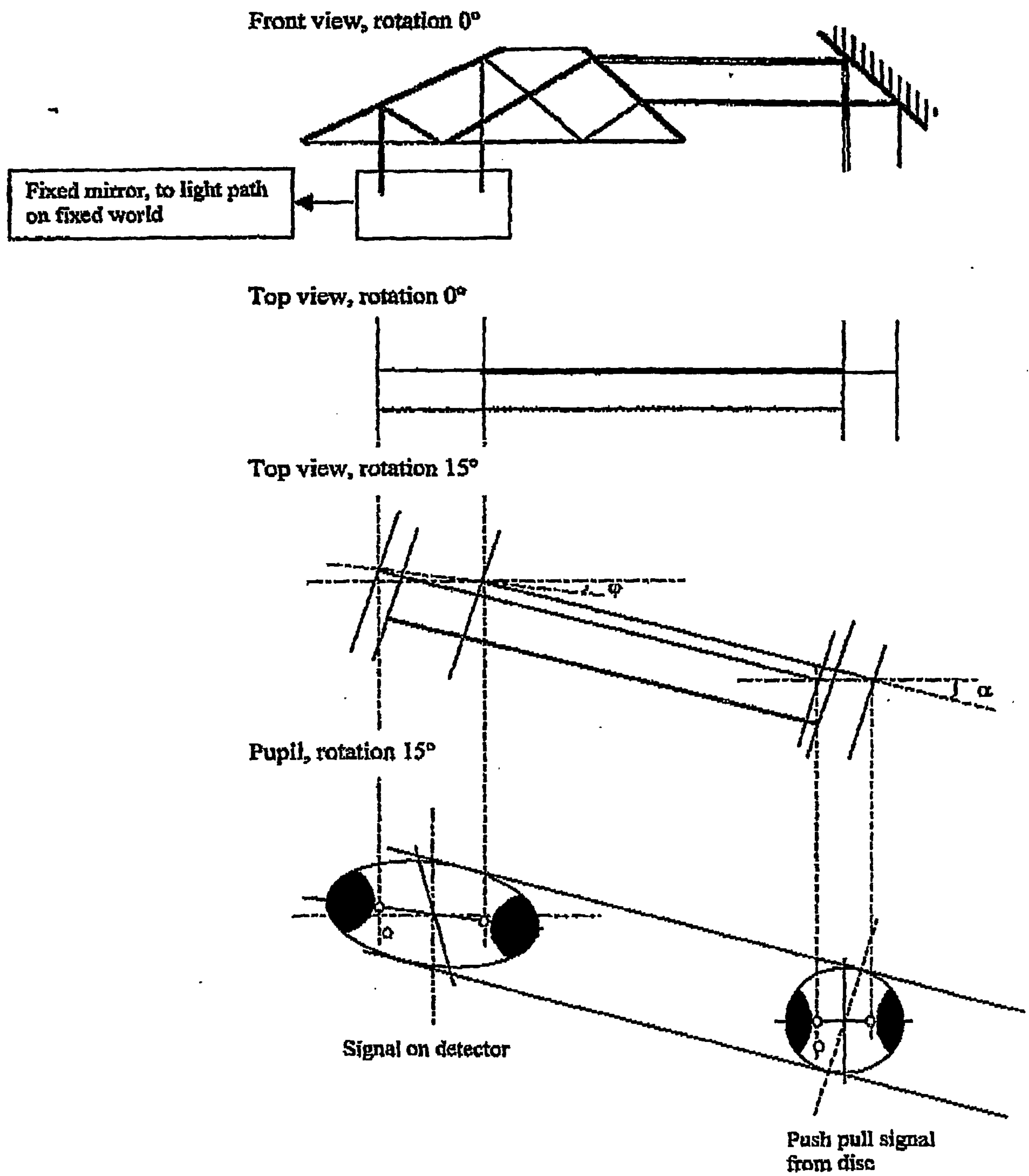


Fig. 4a (alternative of the first embodiment - detailed views)

A-symmetrical prism



Solution with asymmetrical prism. The image will deform, and therefore the image on the detector will be asymmetrical.

Fig. 4b (alternative of the first embodiment - first detailed view)

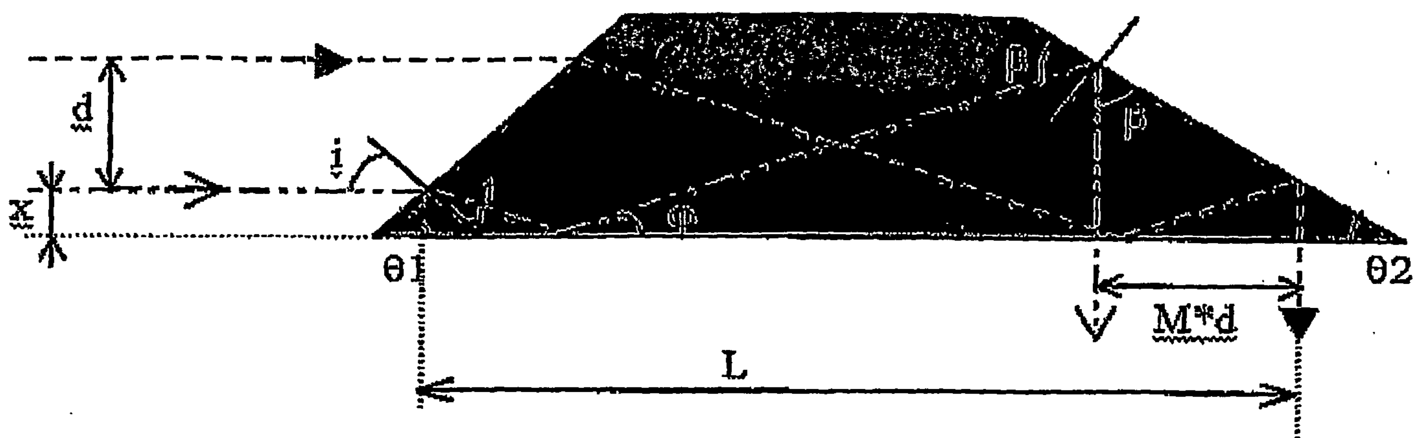


Fig. 4c (alternative of the first embodiment - second detailed view)

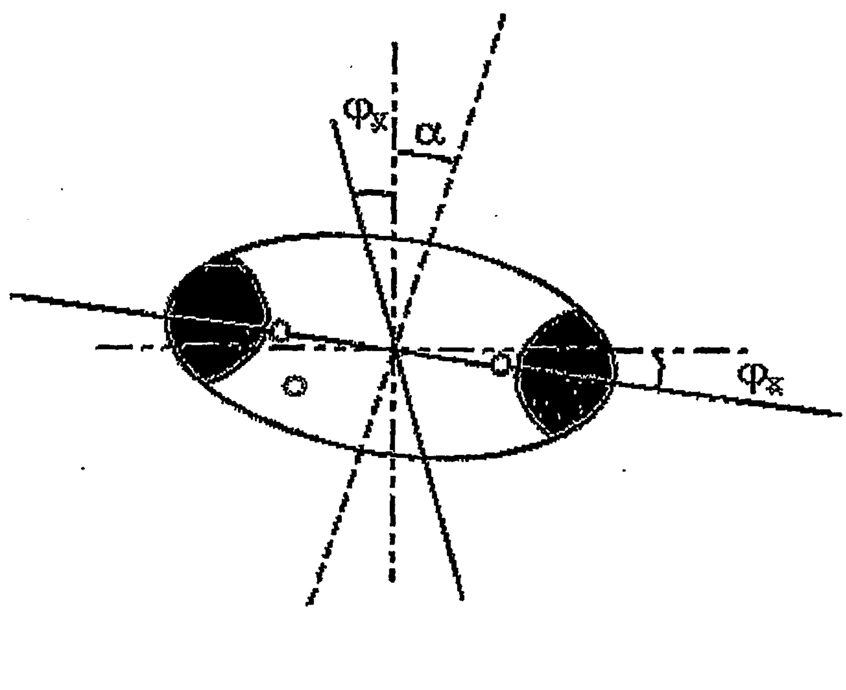


Fig. 4d (alternative of the first embodiment - graph)

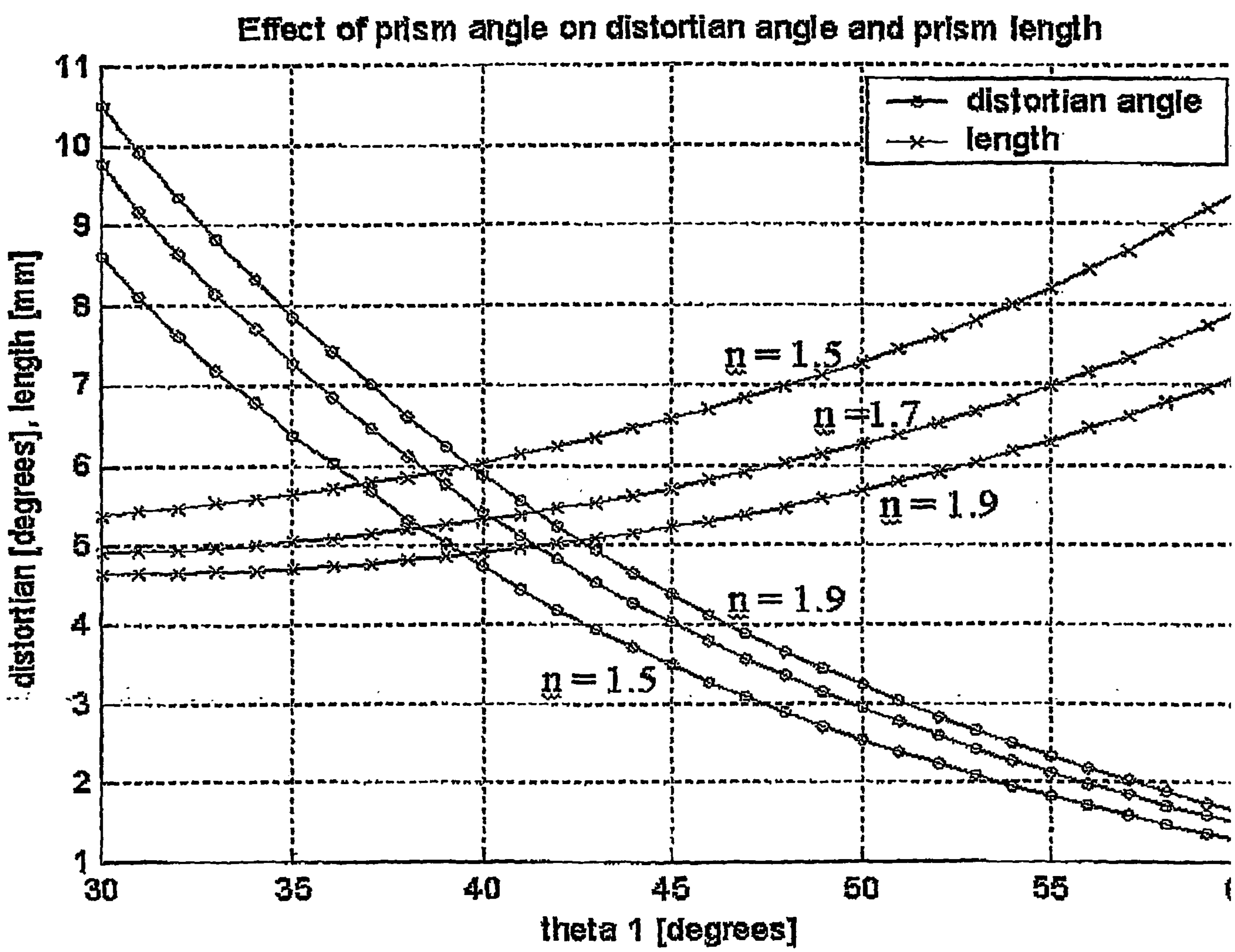


Fig. 5a (orientation of the tracks - first view)

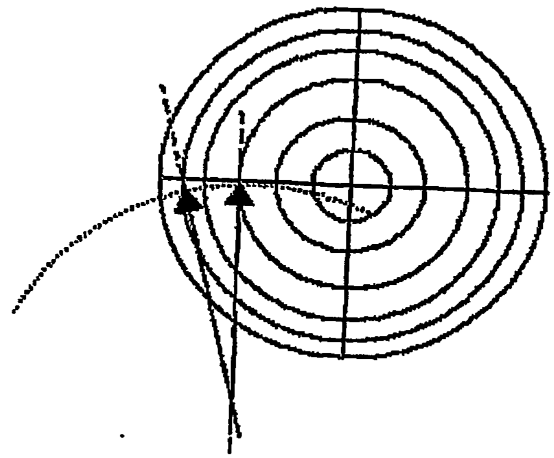
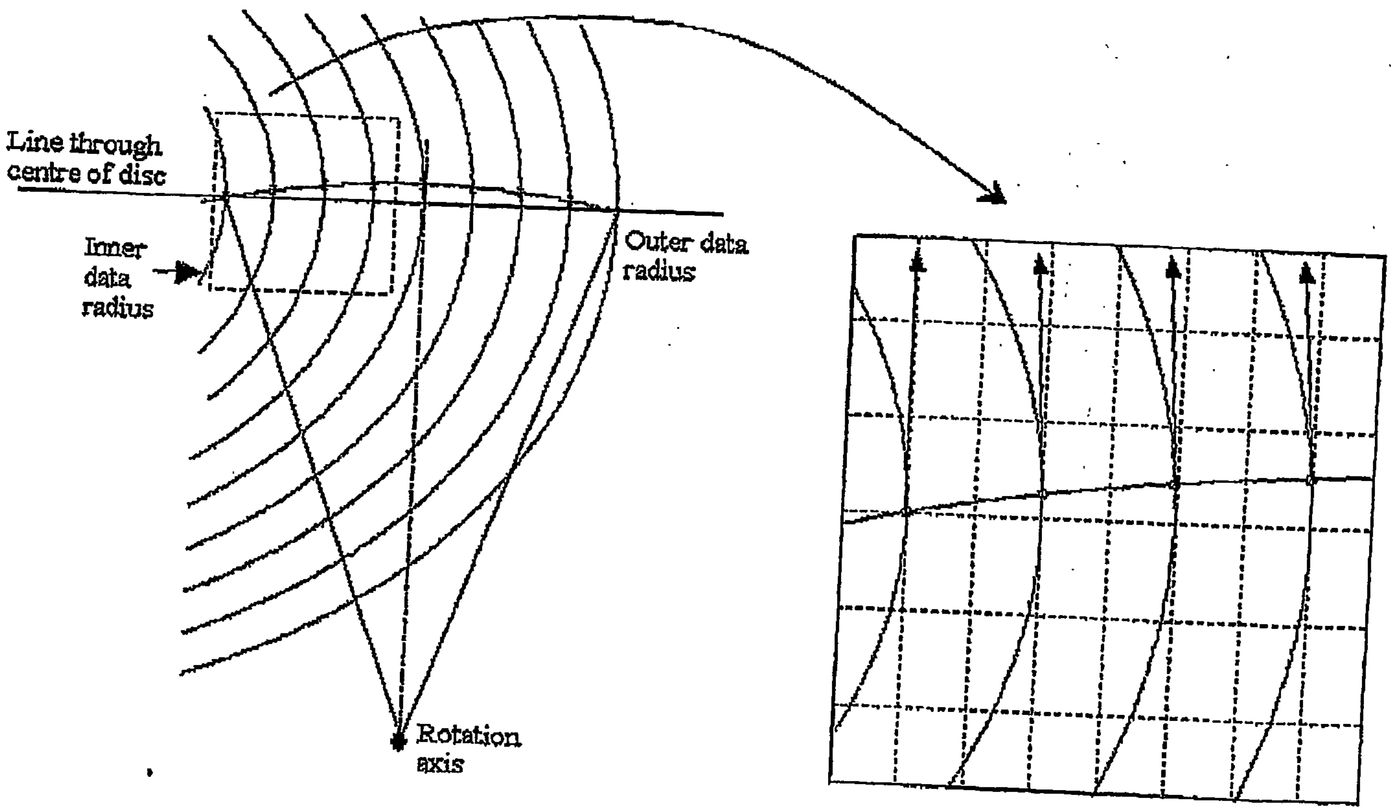


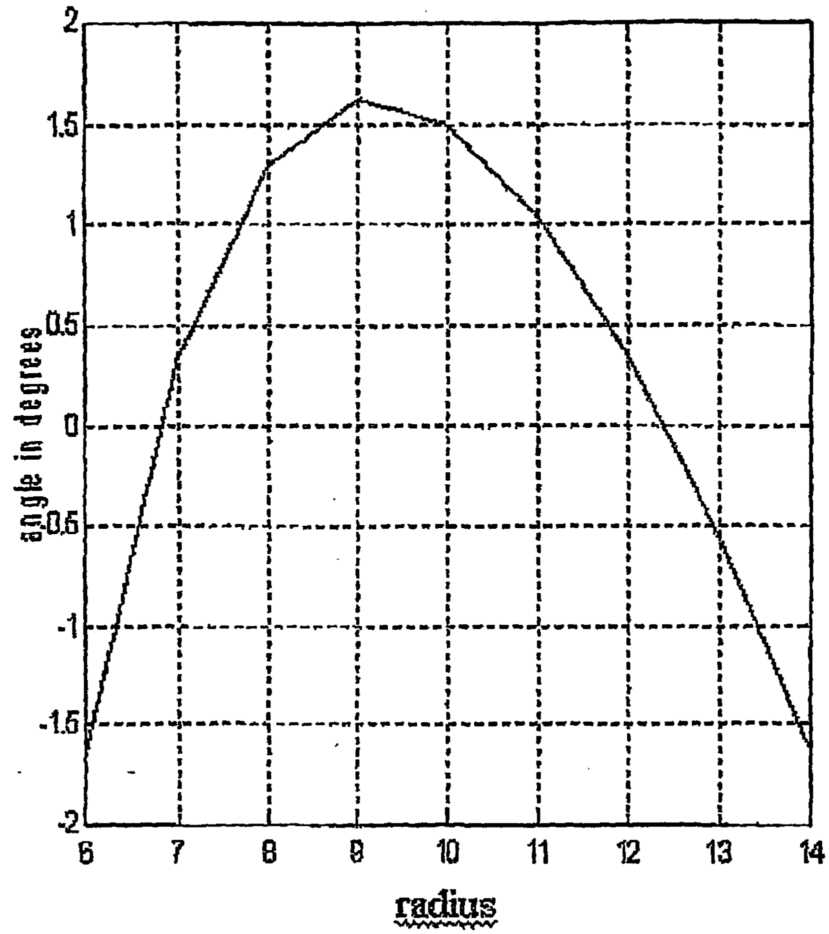
Fig. 5b (orientation of the tracks - second view)



The optimal position for the rotary arm is given on the left. The magnification on the right shows how the orientation of the track changes.

Fig. 5c (orientation of the tracks - third view)

Angle between track and fixed reference

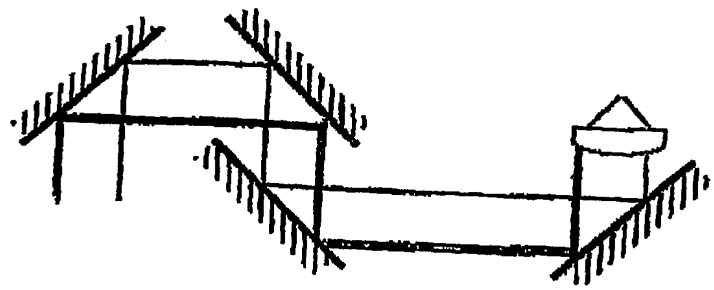


Resulting angle between the tracks and a fixed reference.

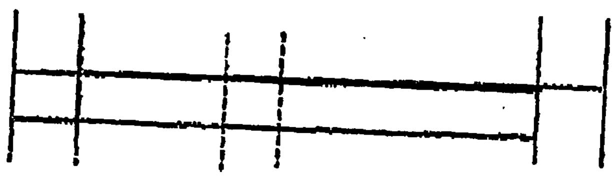
Fig. 6 (second embodiment - schematic view)

Use two extra mirrors to flip image.

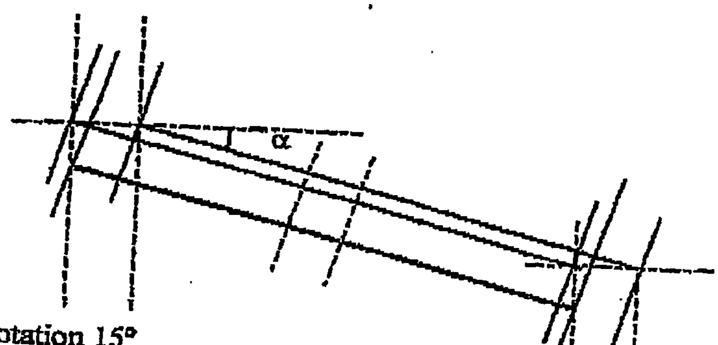
Front view, rotation 0°



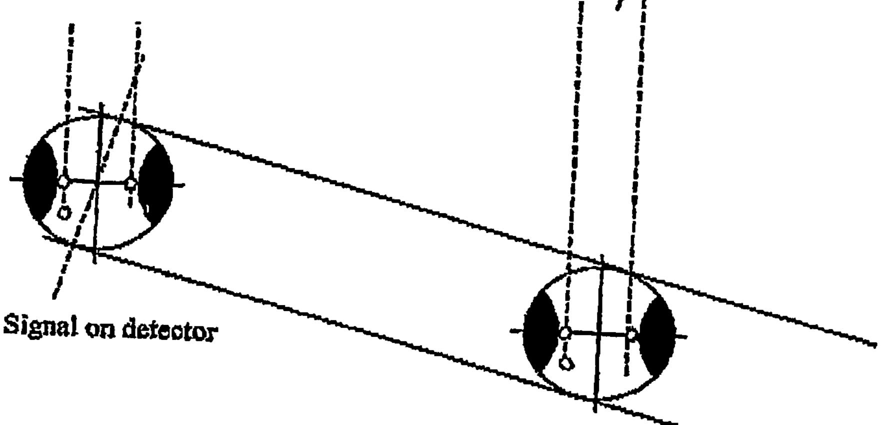
Top view, rotation 0°



Top view, rotation 15°



Pupil, rotation 15°



Push pull signal from disc

Solution with two extra mirrors to flip the image. The building height can be smaller.

Fig. 7a (third embodiment - first example)

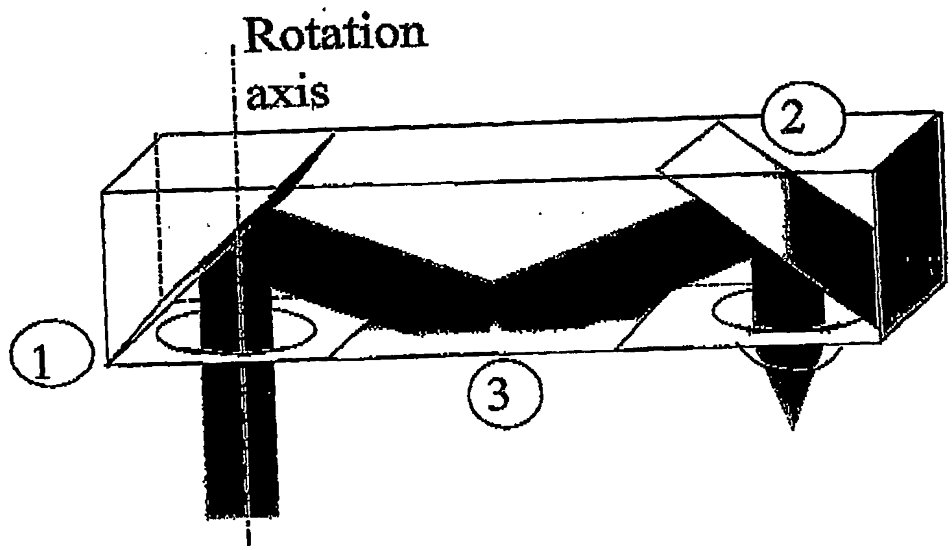


Fig. 7b (third embodiment - second example)

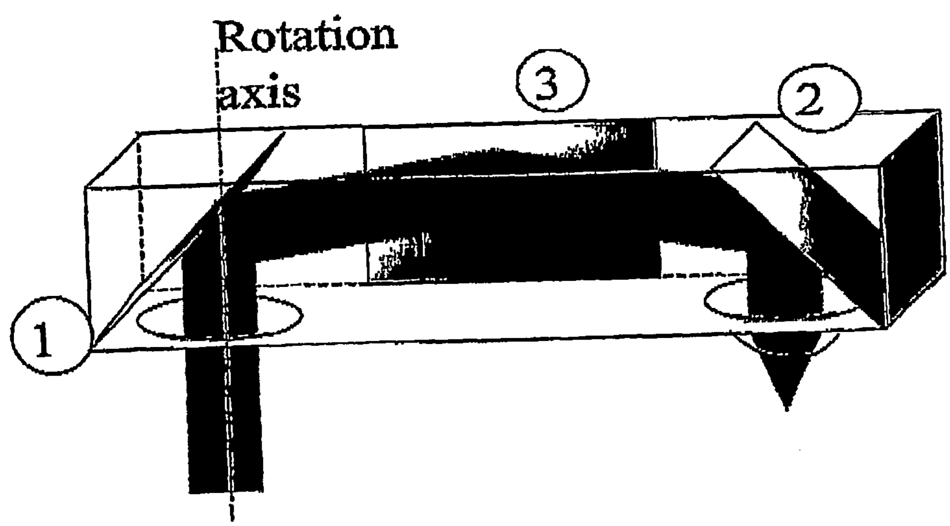
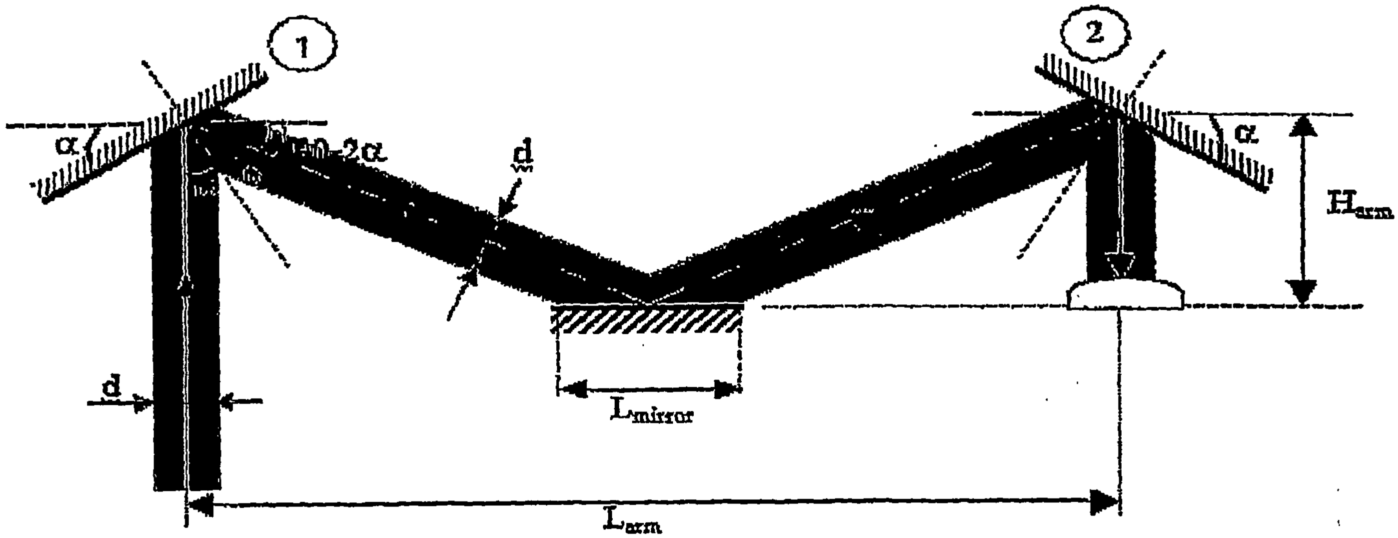


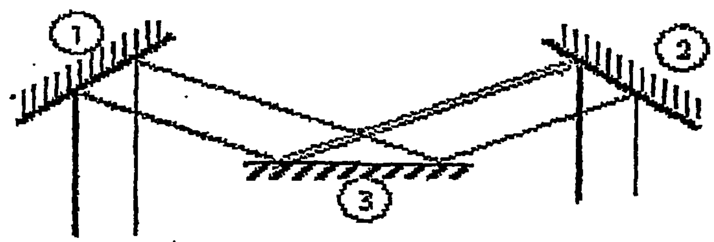
Fig. 7c (third embodiment - first detailed view)



Geometry of configuration with third mirror.

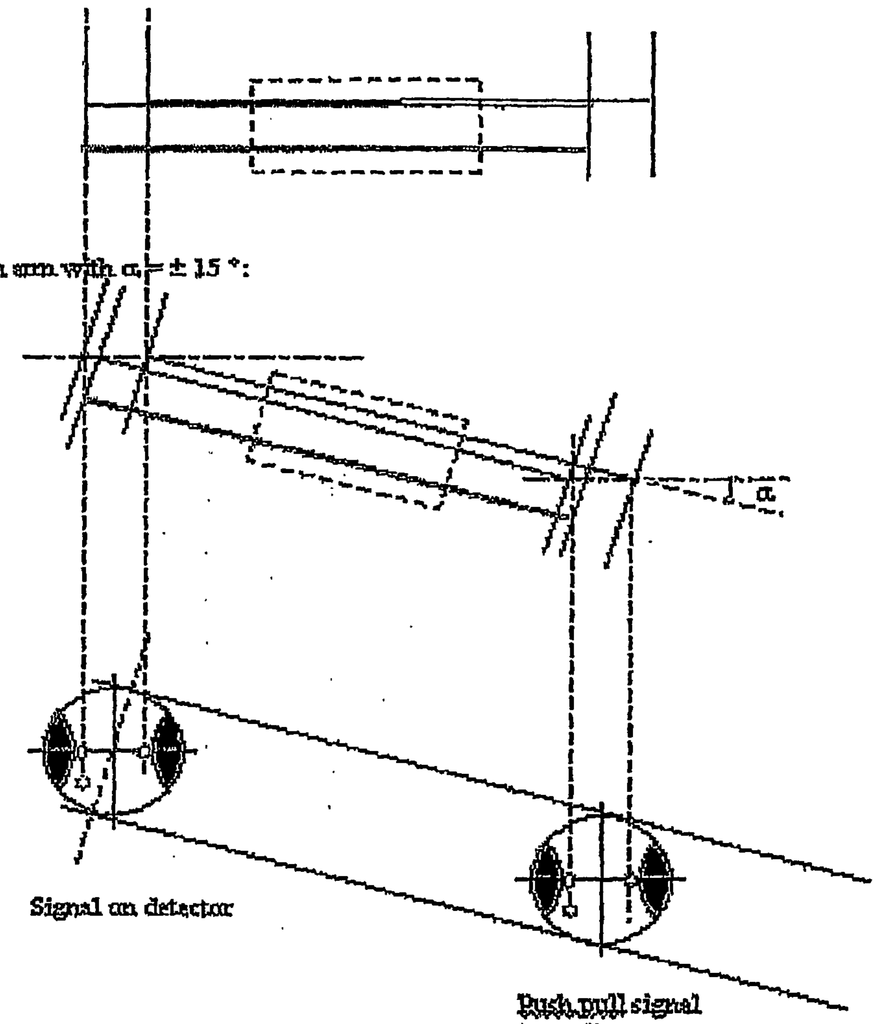
Fig. 7d (third embodiment - second detailed views)

Front view or rotation arm with α = 0°:



Top view of rotation arm with α = 0°:

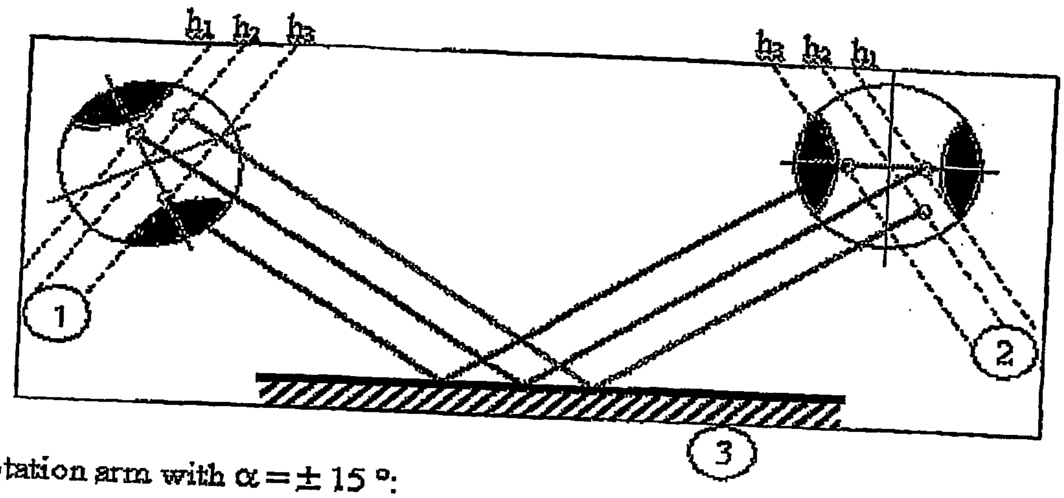
Top view of rotation arm with α = ± 15 °:



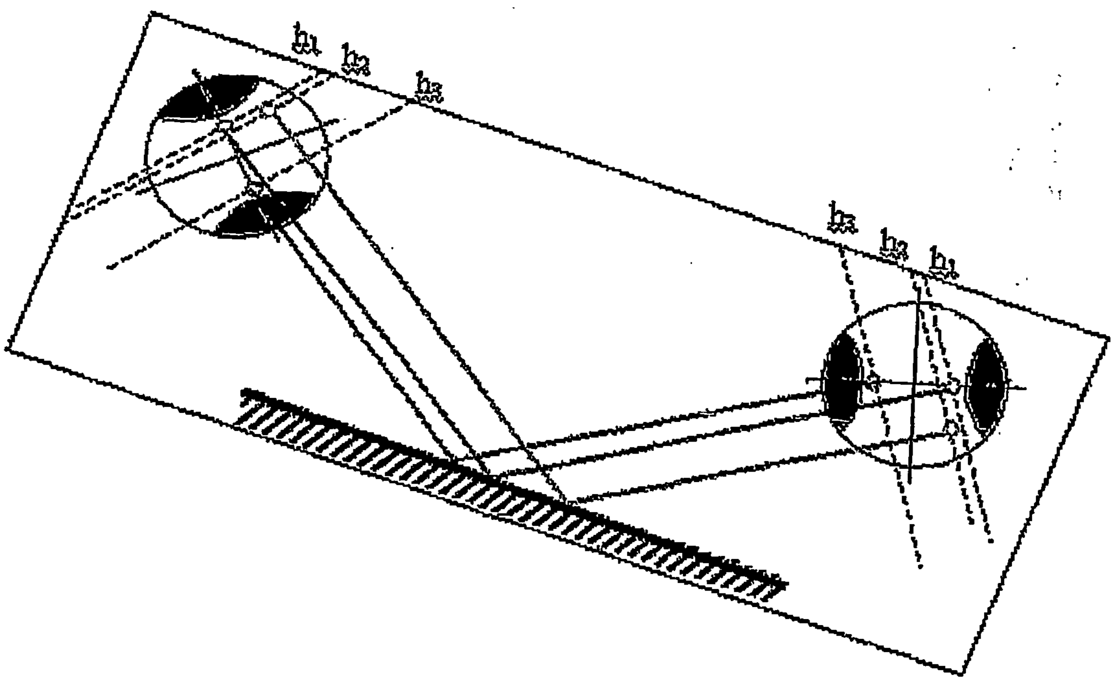
Configuration with third mirror on a horizontal plane.

Fig. 7e (third embodiment - third detailed views)

Top view of rotation arm with $\alpha = 0°$:



Top view of rotation arm with $\alpha = \pm 15°$:



Configuration with third mirror on one of the vertical planes of the rotating arm.

Fig. 8a (fourth embodiment)

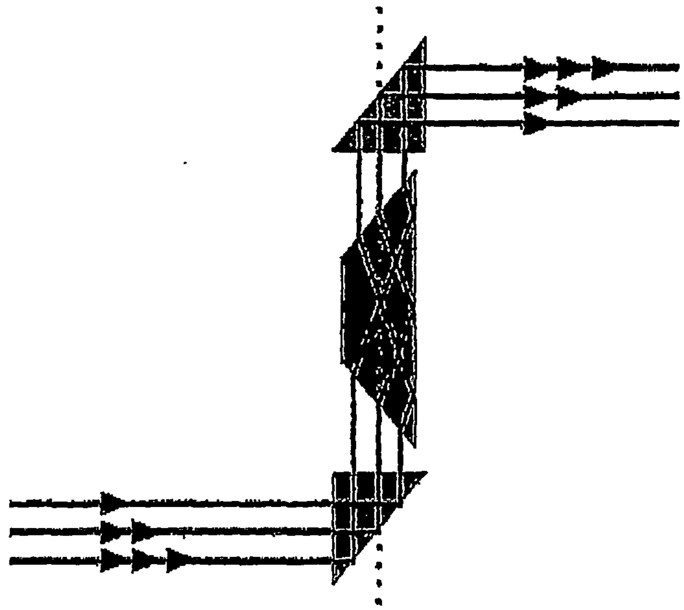


Fig. 8b (fourth embodiment - particular case)